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NAVY SATELLITE OCEANOGRAPHIC RESEARCH PROGRAM (SOREP) PLAN. VOL--ETC(U)
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UNCLASSIFIED U-RC149A-002-VOL-1 NL

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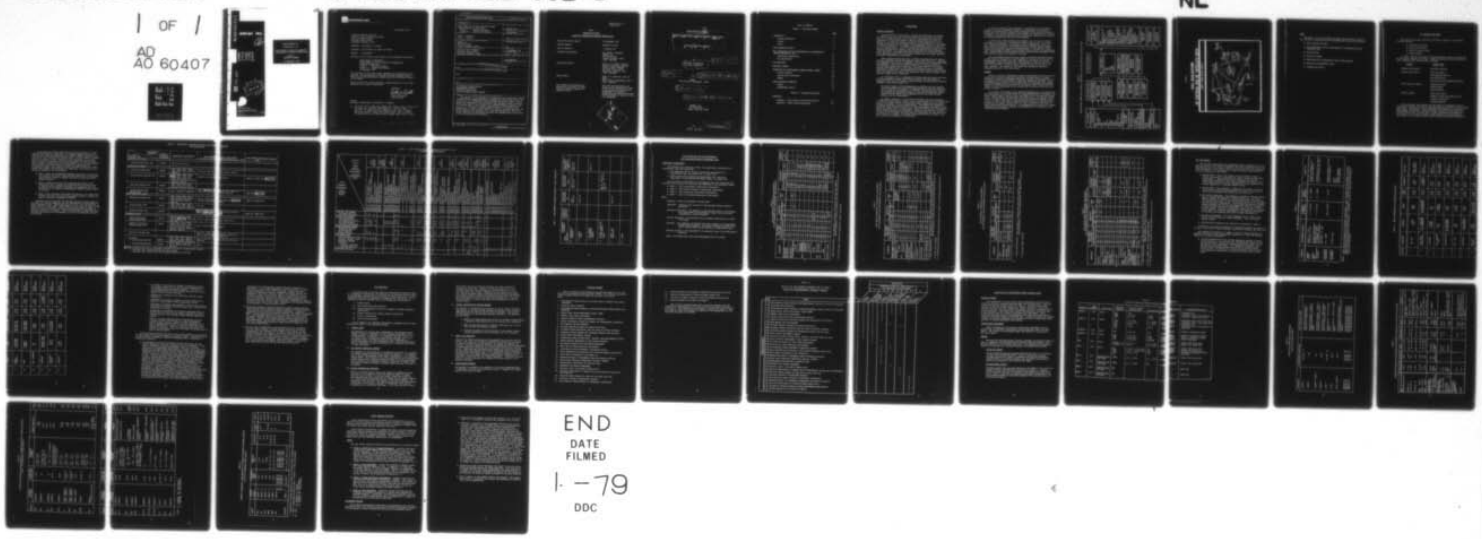

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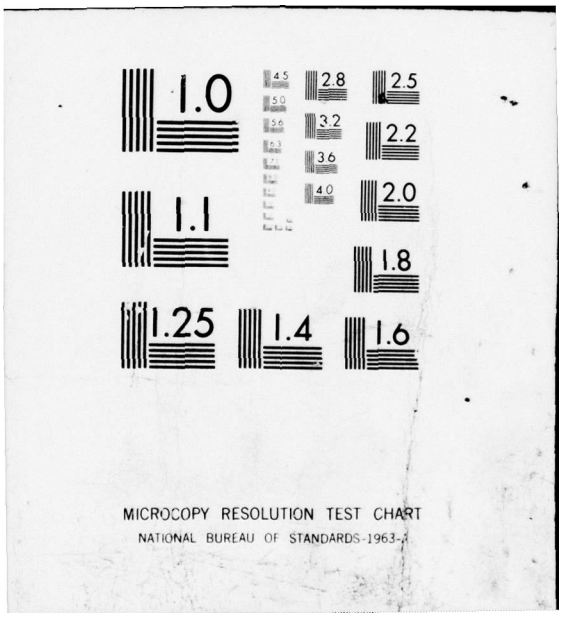
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LEVEL II

RAMCOR REPORT NO.
U-RC149A-002, c.5

FINAL REPORT ON THE NAVY SATELLITE OCEANOGRAPHIC RESEARCH PROGRAM PLAN

VOLUME I
EXECUTIVE SUMMARY

18 September 1978

800 Follin Lane
Vienna, Virginia 22180

RAMCOR INC.
800 FOLLIN LANE VIENNA, VIRGINIA 22180 (703) 281-1666

18 September 1978

Scientific Officer, Code 222
Director, Sensor Technology Programs
Office of Naval Research
800 North Quincy Street
Arlington, Virginia 22217

Attention: CDR Edward J. O'Brien

Reference: ONR Contract No. N00014-77-C-0320

Subject: Final Report

Enclosed is the following final report on the referenced ONR contract:

RAMCOR Report U-RC149A-002
Final Report on the Navy Satellite Oceanographic
Research Program Plan;
Volume I - Executive Summary
Volume II - Program Plan Details.
18 September 1978

The submission of this final report satisfies the requirements of the contract. The distribution of the report follows Enclosure Number 1 under the Unclassified/Limited category along with additional copies to you and NORDA.

Should you have any further questions, please contact me or Mr. Frank Augustine at the number listed above.

Sincerely,

Victor J. Lujetic

Victor J. Lujetic
Vice President

VJL:bem
Enclosure: RAMCOR Report U-RC149A-002 (3 copies)

cc: ACO, DCAS, 300 E. Joppa Road, Towson, Md. 21204 (1 copy - letter only)
Director, NRL, Code 2627, Washington, D. C. 20375 (1 copy)
DDC, Bldg. 5, Cameron Station, Alexandria, VA 22314 (2 copies)
Technical Director, NORDA, NSTL Station, Miss. 39529 (3 copies)
ONR Branch Office, 495 Summer Street, Boston, Mass. 02210 (1 copy)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this document is to define the Navy operational and R&D requirements for oceanographic/marine atmospheric data as they derive from or relate to the fulfillment of Navy missions and warfare tasks. Having defined the requirements and objectives, this document further strives to relate these needs to the current and projected technical program of the U.S. Navy in the area of satellite remote sensing, to determine their adequacy and to suggest changes needed (if any) to guarantee that Navy and Marine Corps priority needs are met. This program plan will serve as a single technology and management reference for implementation and planning of Navy related satellite programs.

RAMCOR Report No.
U-RC149A-002

FINAL

REPORT ON THE NAVY

SATELLITE OCEANOGRAPHIC RESEARCH PROGRAM PLAN

Date of This Final Report	18 September 1978
Contract Number:	N00014-77-C-0320
Date of Contract:	1 January 1977
Principal Investigator	Mr. Frank J. Augustine RAMCOR, Inc. 800 Follin Lane Vienna, Virginia 22180 (703) 281-1666
Scientific Officer:	CDR. E. J. O'Brien, Code 222 Acoustic Technology Programs Office of Naval Research 800 North Quincy Street Arlington, Virginia 22217 (703) 696-4208
NORDA Officer:	CAPT. G. D. Hamilton, Code 310 NORDA NSTL Station, Mississippi 39529 (601) 688-4650

This research was sponsored and monitored by the Office of Naval Research under ONR Contract No. N00014-77-C-0320

(6) FINAL REPORT ON THE NAVY

SATELLITE OCEANOGRAPHIC RESEARCH PROGRAM (SOREP) PLAN

VOLUME I: EXECUTIVE SUMMARY

By

(10) Frank J. Augustine
Victor J. Lujetic

(11) 18 Sep 78

(12) 45 p.

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NSTL Station, Mississippi 39529

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RAMCOR, Inc.
800 Follin Lane
Vienna, Virginia 22180

TABLE OF CONTENTS

VOLUME I - EXECUTIVE SUMMARY

VOLUME II - PROGRAM PLAN DETAILS

INTRODUCTION

GENERAL BACKGROUND

The performance of naval ships, aircraft and submarines, the weapons and sensors they carry, and the naval and marine corps personnel who man them is intimately related to the condition, particularly the ocean and atmosphere, in which they operate. There is ample evidence, some of it bitter, in our national military experience of situations where a lack of knowledge concerning the environment has had profound effects on the outcome of military operations. An example is the amphibious assault on Tarawa by the U.S. Marines where a lack of environmental information resulted in heavy casualties because their landing craft had bottomed out several hundred yards from shore. An example with better results is the successful Allied D-Day amphibious landing on the Normandy beaches which was highly dependent on weather information and conditions.

These examples demonstrate that a profound relationship exists between military operations and the environment in which they take place. Commanders must appreciate the variety, variability, and dynamics of environmental interrelationships. Their military needs demand that a vigorous program of environmental measurement be conducted. The global nature of our present military committments means global measurement programs must be conducted. Technically, politically, and economically, satellite remote sensing systems offer the capability to furnish the environment data needed to support quick reaction global military operations.

On 12 February 1975, in recognition of these needs and also of the capabilities afforded by present and future satellites, the Navy formally established the Naval Environmental Remote Sensing and Coordinating Committee (NERSCAC), whose stated mission is:

> "To provide support and recommendations to ASN(R&D) and the Director, Space and Command and Control and Communications C^3 Division (NOP-986), in his capacity as coordinator, in planning, coordinating and implementing research and development aspects of the Navy Environmental Remote Sensing Program (NERSP) and as appropriate with the Chief of Naval Research and the Oceanographer."

The NERSP, referred to in the mission statement, has never existed as a formally defined program. Rather, it was, and continues to be, a descriptive term for the loosely related environmental remote sensing activities being conducted throughout the naval establishment. The NERSCAC has attempted to coordinate these activities primarily to avoid unnecessary duplication and to ensure the prudent use of limited fiscal resources available for environmental remote sensing research and development. Having no line authority and with the Navy having no single individual directly responsible for the conduct and coordination of the NERSP, the NERSCAC has achieved whatever success it has had by collective bargaining and compromise.

In 1976, the Chief of Naval Research, in realization of his responsibilities to conduct fundamental research in oceanography as dictated by statute and as directed by the Assistant Secretary of the Navy for Research, Engineering, and Systems (ASNRE&S), tasked NORDA, an ONR-subordinate activity, to prepare a plan describing the Navy's requirements, objectives, and current and planned programs for satellite remote sensing.

In March 1978, NORDA contracted with RAMCOR, Inc. of Vienna, Virginia to assist in preparation of the Satellite Remote Sensing Plan. Up to this time, NORDA had collected a substantial amount of programmatic data from Navy activities involved in environmental sensing research and development, mostly from individuals who were also participants in the NERSCAC. These data were furnished to RAMCOR to be organized into a research and development plan. NORDA further directed RAMCOR to avoid addressing any management issues that were not properly the subject of the plan.

The first RAMCOR report entitled, "Report on the Navy Satellite Oceanographic Research Program Plan," was delivered to the Navy on 18 May 1978 and an addendum to this report entitled, "Addendum to the Report on the Navy Oceanographic Research Program Plan," was delivered to the Navy on 28 June 1978. In July 1978, a review of these reports was held at the Office of Naval Research. The results of that review and discussions with Navy personnel resulted in this final report.

PURPOSE

The Navy satellite oceanographic research program must relate the environmental data to military missions, operations, and applications. Figure 1 indicates the general relationships among data sources, data acquisition, data utilization, and the applications of satellite information and data. These interrelationships are part of the overall plan in instituting this research program and achieving the objectives of the program, which should eventually result in a full realization of the tactical use of satellite data as illustrated in Figure 2.

As a result, the purpose of the document presented here is to define the Navy operational and R&D requirements for oceanographic/marine atmospheric data as they derive from or relate to the fulfillment of Navy missions and warfare tasks. Having defined the requirements and objectives, this document further strives to relate these needs to the current and projected technical program of the U.S. Navy in the area of satellite remote sensing, to determine their adequacy and to suggest changes needed (if any) to guarantee that Navy and Marine Corps priority needs are met. This program plan will serve as a single technology and management reference for implementation and planning of Navy related satellite programs.

FIGURE 1

RELATIONSHIPS AMONG DATA SOURCES, ACQUISITION, AND UTILIZATION AND APPLICATIONS

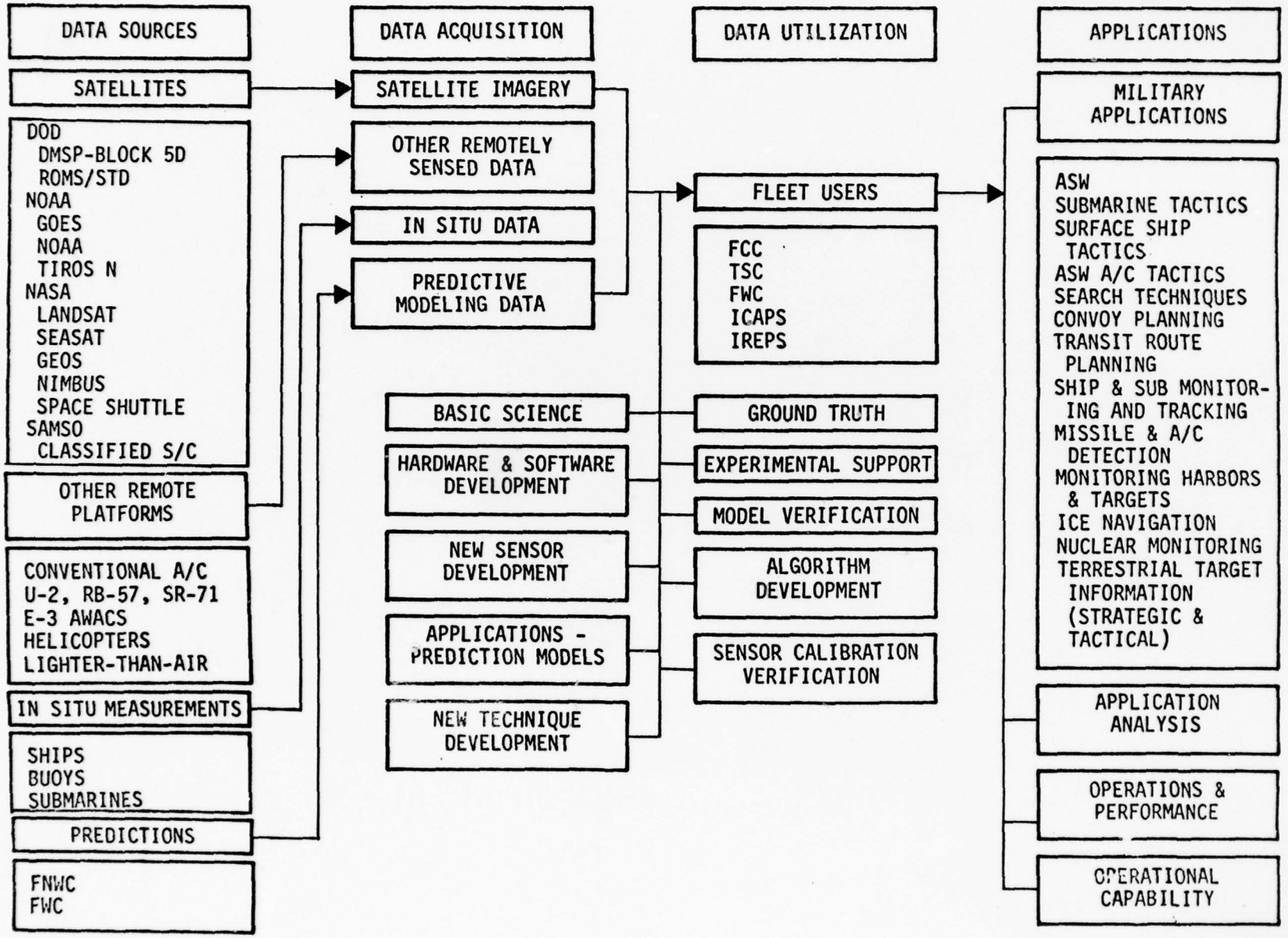
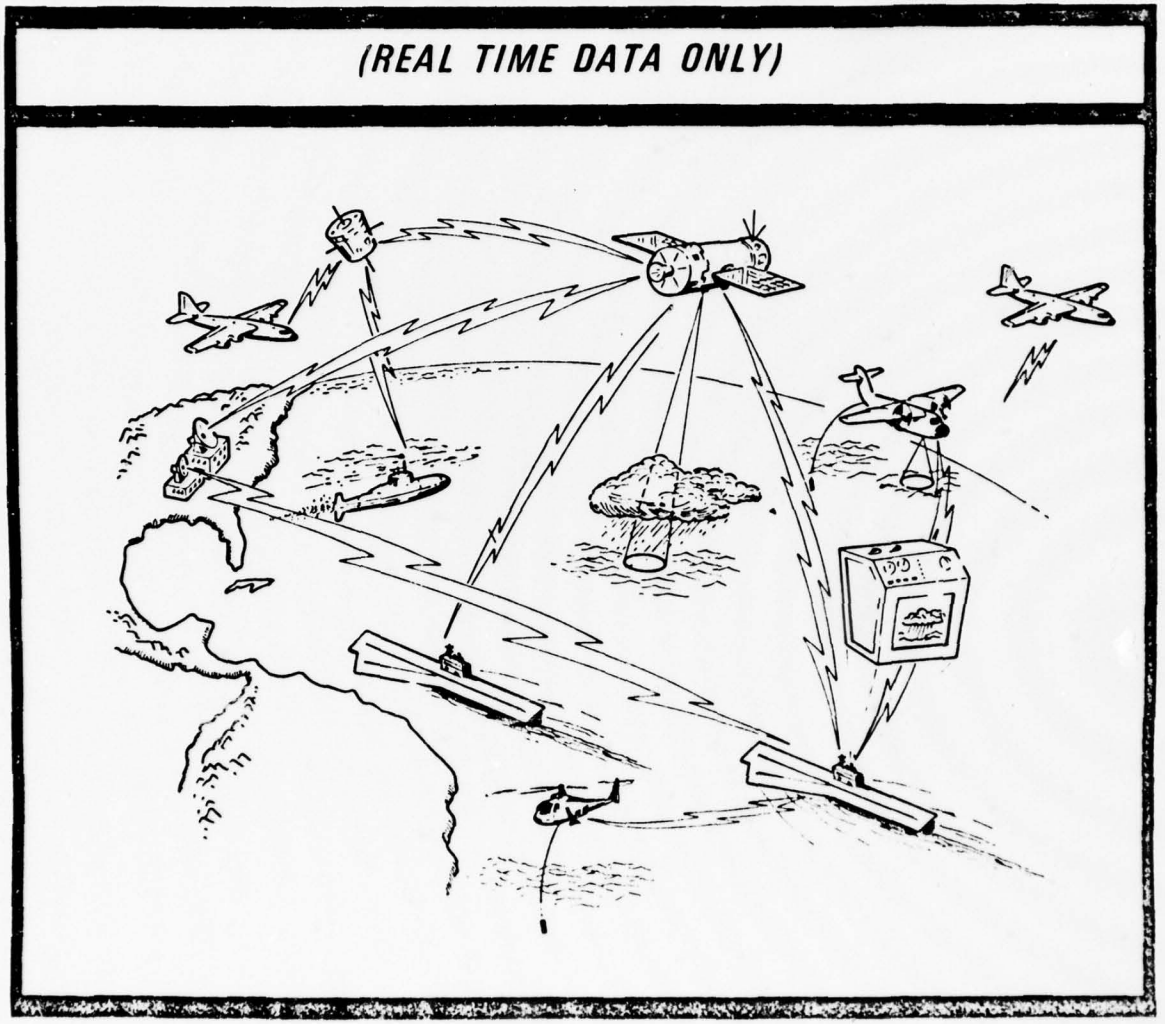


FIGURE 2

FULL REALIZATION OF TACTICAL USE OF SATELLITE DATA

(REAL TIME DATA ONLY)



SCOPE

The scope of this effort addresses remote sensing systems operating from existing or projected satellite platforms and involves the following:

- Navy missions and tasks
- Navy operational and R&D requirements for oceanographic/marine atmosphere data
- R&D objectives
- Technical program
- Operational and developmental remote sensing systems
- Technical and management issues
- Program plan details

NAVY MISSIONS AND TASKS

The Navy has four basic missions to perform in support of the national military strategy:

- Strategic Sea Control
- Tactical Sea Control
- Power Projection Ashore
- Mission Support

Of these, Tactical Sea Control and Power Projection Ashore are designated as the primary missions of the Navy. These Navy missions can be divided into their component naval warfare tasks as follows:

MISSION	WARFARE TASK
Strategic Sea Control:	Sea-Based Deterrent
Tactical Sea Control:	Anti-Air Warfare
	Anti-Submarine Warfare
	Anti-Ship Warfare
	Mine and Mine Countermeasures Warfare
Power Projection Ashore:	Amphibious Warfare
	Strike Warfare
	Special Warfare
Mission Support:	Ocean Surveillance
	Command, Control and Communications
	Support and Logistics
	Personnel/Medical

This division of Navy missions has the purpose of developing the naval forces, weapon systems, and tactical doctrines that are required to ensure overall proficiency. The details of naval operations and procedures are set forth in naval warfare publications. Since the conduct of naval warfare requires an understanding of both the broad types of naval operations and missions and the methods for their accomplishment, certain aspects of the employment of naval forces in the component naval warfare tasks are described in Appendix A.

The missions and warfare tasks of the Navy form the basis for determining those technical, operational and personnel capabilities that the Navy must have under the constraints of a limited defense expenditure and oriented to a very specific and serious threat. In fact, unless a development can be shown to relate in some way to an enhancement of the naval warfare capabilities listed, serious questions about its naval relevancy must be raised. Consequently, as much as possible of the existing requirements documentation was reviewed to determine if requirements for environmental support data capable of being furnished by satellite remote sensors were stated either explicitly or implicitly. The results of this review are summarized in the following:

- Table 1 shows the requirements documents that apply to each of the Navy missions and warfare tasks discussed previously and indicates which documents appear to support the need for satellite oceanographic research.

- Table 2 matches the current Naval Research Requirements (ONR Instruction 3910.2) against the naval missions and warfare tasks to identify which research requirements are compatible with the objectives for the Satellite Oceanographic Research Program (SOREP) of the Navy.

- Table 3 cross references these SOREP objectives to the requirements documents and again indicates which document appears to support the need for satellite oceanographic research.

Therefore, the Navy missions and functions and naval warfare tasks are the source of the Navy operational and R&D requirements for oceanographic/marine atmospheric data. These requirements in turn, form the basis for the objectives of the Navy SOREP. These objectives then become the goals of the Navy's technical program and the basis for determining which programs to initiate, continue, or terminate. These R&D Requirements, SOREP Objectives, and Technical Program will be addressed in turn in the subsequent sections of this plan.

Table 1. REQUIREMENTS DOCUMENTS RELATED TO NAVY MI
AND WARFARE TASKS

REQUIREMENTS DOCUMENTS / NAVY MISSIONS & WARFARE TASKS	SCIENCE & TECHNOLOGY OBJECTIVES	OPERATIONAL REQUIREMENTS	NAVAL WARFA as listed in NWP
STRATEGIC SEA CONTROL			
Sea-Based Deterrent (SB)	STO/SB	SB 01, SB 16, SB 25	
TACTICAL SEA CONTROL			
Anti-Air Warfare (AA)	STO/AA	AA10, AA24, AA27, AA28, AA29, AA82, AA94, Ø916-AA, 1Ø22-AA	NWP 12-1, NWP 17,
Anti-Submarine Warfare (AS)	STO/AS	ASØ1, ASØ2, ASØ3, ASØ6, AS15, AS30, AS55, AS61, AS82, AS84, S0210-AS, SO239-AS, 0229-AS, 0907-AS, 0927-AS, 0932-AS	NWP 55-2-1, NWP 5
Anti-Ship Warfare (SH)	STO/SH	SH38, SH39, SH44, SH45, SH50, 0301-SH, 0858-SH, 0957-SH, 0913-SH, 1031-SH	
Mine/Countermeasures Warfare (MW)	STO/MW	MW 20, SØ257-MW, SØ86Ø-MW	NWP 26, NWP 27, N NWP 27-3, NWP 27-
POWER PROJECTION ASHORE			
Amphibious Warfare (AW)	STO/AW	AWØ1, AWØ2, AWØ8, AW13, Ø861-AW, Ø863-AW, Ø877-AW, Ø879, Ø929-AW, Ø5Ø7-AW, Ø93Ø-AW	NWP 22, NWP 22-2, NWP 22-5, NWP 22-
Strike Warfare (TW)	STO/TW	TWØ1, TWØ2, TWØ3, TWØ4, TW30, TW33, TW38, 0626-TW, 0873-TW, 0947-TW, WØ975-TW	NWP 20,
Special Warfare (SW)	STO/SW		NWP 13-1, NWP 15, NWP 40, NWP 15-1*
SUPPORTING TASKS			
Ocean Surveillance (Intelligence) (OS)	STO/OS	Ø866-OS, Ø878-OS, 0562, Ø760-OS, WØ527-OS, W1Ø27-OS, RØ123-OS	NWP 11, (NWP 12-4)
Command, Control and Communications (CC)	STO/CC	CC20, CC33, CC34, CC38, CC45R1, CC70, CC71, CC72, CC73, CC88, CC92, CCA8, Ø733-CC, Ø697-CC, Ø960-CC, X0997CC, 1026-CC	NWP 4, NWP 5, NWP
Electronic Warfare (EW)			NWP 12-6, (NWP 12- NWP 31, NWP 33, N
Logistics -- Support&Logistics (SL)	STO/SL	SLØ1, SLØ4, SL65, SL67R1, SLF7, SLH1, SLJH, Ø859-SL, Ø925-SL, Ø931-SL, 1019-SL	NWP 14, NWP 14-1, NWP 22-8,
-- Personnel/Medical (PN)	STO/PN	PN 45, PN 47, PN 50, PN 51, PN 52, Ø884-PN, Ø953-PN, 1003-PN	NWP 6

[ ] Indicates some type of requirement related to satellite oceanographic research
( ) Indicates that a publication has yet to be issued
* Indicates that document has been released subsequent to NWP Ø(H)

MISSIONS

RFARE PUBLICATIONS NP ø(H) (Issued April, 1976)	NAVAL WARFARE INFORMATION PUBLICATIONS
17, NWP 31, NWP 32,	
WP 55-2-2	NWIP 24-3, NWIP 23-1, NWIP 23-9
27, NWP 27-1, NWP 27-2, 27-4, NWP 27-5,	NWIP 26-1, NWIP 27-1,
22-2, NWP 22-3, NWP 22-4, 22-8	NWIP 22-1, NWIP 22-6,
15, NWP 21, NWP 22-4, 5-1*	NWIP 29-1, NWIP 29-2,
12-4), NWP 55-7-1,	
NWP 11	
12-6-1), NWP 12-6-2, 3, NWP 33-1	
1-1, NWP 11, NWP 22-3,	

Table 2. NAVAL RESEARCH REQU
PLANNIN

RDT&E PLANNING CATEGORIES (Naval Warfare Areas) / ONR INST. 3910.2 NAVAL RESEARCH REQUIREMENTS (Research Requirements Area)	R011 General Physics							R012 Nuclear Physics		R013 Chemistry					R014 Mathematics									R021 Electronics			
	R011-02 Solid-State Physics	R011-03 Atomic & Molecular Physics	R011-07 Radiation & Optics & Laser Physics	R011-08 Acoustics	R011-09 Plasma & Ionic Physics	R011-11 Superconductivity		R012-04 Radiation Environment	R012-06 Radiation Interactions	R013-01 Physical Chemistry	R013-02 Chemical Non-metallic Materials	R013-05 Analytical Chemistry	R013-08 Solid State Chemistry	R013-09 Chemical Synthesis & Mechanisms	R014-02 Applied Mathematics	R014-03 Numerical Analysis	R014-05 Mathematical Statistics & Probability and Engineering Applications	R014-07 Theories & Techniques of Logistical Analysis & Operations Research	R014-08 Theories & Techniques of Information Processing	R014-09 Information Processing Devices	R014-11 Methodology for Systems Analysis		R021-01 Electromagnetic Wave Propagation & Radiation	R021-02 Physical Electronics	R021-03 Electronic Components	R021-05 Electronic Systems & Communication Theory	
STRATEGIC SEA CONTROL																											
Sea-Based Deterrent	X	X	X		X										X	X	X						X		X		
TACTICAL SEA CONTROL																											
Anti-Air Warfare	X	X	X		X										X	X	X				X		X		X	X	
Anti-Submarine Warfare	X	X	X	X		X				X	X	X	X	X	X	X	X				X		X		X	X	
Anti-Ship Warfare	X		X	X						X	X	X	X	X	X	X	X				X		X		X		
Mines/Countermeasures	X	X	X	X		X											X	X									
POWER PROJECTION ASHORE																											
Amphibious Warfare	X														X	X	X	X					X				
Strike Warfare	X		X												X		X							X		X	
Special Warfare	X	X	X		X												X							X	X	X	
SUPPORTING TASKS																											
Ocean Surveillance (Intell.)	X	X	X	X	X	X									X	X	X				X		X		X	X	
Command, Control & Comm.	X	X	X	X	X	X		X	X						X	X	X	X	X	X	X		X		X	X	
Electronic Warfare																											
Logistics																											
-- Support & Logistics										X	X	X	X	X			X	X	X	X						X	
-- Personnel/Medical																	X	X									
OBJECTIVES FOR SOREP																											

QUIREMENTS RELATED TO RDT&E
NING CATEGORIES

														R021-05	Electronic Systems & Communication Theory	
				X	X	X	X	X		X	X	X	X	R022-01	Physical & Mechanical Metallurgy	R022 Materials
				X	X	X	X		X	X	X	X	X	R022-02	Ceramics, Glasses & Related Inorganic Solids	
						X				X	X	X	X	R022-04	Composite Materials	
				X	X	X	X	X	X	X	X	X	X	R022-06	Special Materials & Techniques	
						X	X	X	X	X	X	X	X	R022-08	Surface Phenomena, Corrosion & Prevention	
				X					X	X	X	X	X	R022-11	Radiation-Resistant Materials	
					X	X				X	X		X	R023-01	Hydrodynamics	R023 Mechanics
						X	X	X	X	X	X	X	X	R023-02	Aeromechanics	
	X									X	X	X	X	R023-03	Structural Mechanics	
				X	X	X	X	X	X	X	X	X	X	R024-01	Electrical Power Generation	R024 Energy Conversion
					X	X	X	X	X	X	X	X	X	R024-02	Principles of Chemical Propulsion & Armaments	
						X	X	X	X	X	X	X	X	R024-03	Energy Utilization	
		X		X	X			X	X		X		X	R031-01	Ocean Science Engineering	R031 Oceanography
				X	X			X	X		X			R031-02	Oceanic Biology	
III II		X		X	X				X	X	X	X	X	R031-03	Oceanography	
		X		X			X	X	X		X		X	R032-01	Earth Physics	R032 Terrestial Sciences
V IV		X				X	X	X	X					R032-04	Geography	
	X	X		X	X		X	X	X		X		X	R032-05	Arctic Research	
				X	X					X	X	X	X	R032-08	Environmental Factors	
I		X		X			X	X				X	X	R033-02	Atmospheric Sciences	R033 Atmospheric Sciences
				X	X	X		X		X		X		R033-03	Geophysical Effects	
	X			X	X							X	X	R034-06	Astronomy and Astrophysics	R034
	X													R041-01	Physiology	R041 Biological & Medical Sciences
	X													R041-02	Immunalogy and Hematology	
	X													R041-05	Microbiology	
	X													R041-06	Biochemistry	
	X													R041-08	Biophysics	
	X													R041-09	Epidemiology	
	X													R041-20	Clinical Medical Sciences	
	X													R041-26	Naval Biology	
	X													R042-04	Personnel Utilization	R042 Behavioral & Social Sciences
	X													R042-06	Learning and Training	
	X													R042-08	Organization Effectiveness	
	X	X		X										R042-09	Engineering Psychology	
	X	X	X	X	X	X	X	X	X	X	X	X	X	R000	Navy In-House Laboratory Independent Research Area	R000

Table 3. REQUIREMENTS DOCUMENTS RELATED TO SOREP OBJECTIVES

SOREP OBJECTIVE / REQUIREMENTS DOCUMENTS	SCIENCE AND TECHNOLOGY OBJECTIVES	OPERATIONAL REQUIREMENTS OR	NAVAL WARFARE PUBLICATIONS NWP	NAVAL WARFARE INFORMATION PUBLICATIONS NWIP
III. THERMOHALINE STRUCTURE		AS15, W0527-OS	NWP 27, NWP 15-1, NWP 22-4	NWIP 23-9, NWIP 27-1
II. SURFACE WINDS		W0527-OS		
I. SEA SURFACE DIRECTIONAL SPECTRA				NWIP 27-1
IV. COASTAL CONDITIONS OF ISW SIGNIFICANCE			NWP 27, NWP 22-4 NWP 15-1, NWP 13-1, NWP 15	
V. ARCTIC ICE CONDITIONS		W0527-OS		
VI. OTHER				

NAVY OPERATIONAL AND R&D REQUIREMENTS FOR OCEANOGRAPHIC/MARINE ATMOSPHERIC DATA

OPERATIONAL REQUIREMENTS

The following two references outline the operational requirements for environmental data from satellites.

- JCS memorandum 251-76, Military Operational Requirements for Environmental Data from Satellites, 31 August 1976.
- OP094 letter 612149, Operational Requirement (OR); Satellite Measurement of Oceanographic Parameters (SMOP), 10 August 1976.

The operational requirements for environmental data from satellites were extracted from the above two references and summarized in the following tables:

- Table 4 - Navy oceanographic operational requirements
- Table 5 - Navy marine atmospheric operational requirements
- Table 6 - Navy terrestrial operational requirements
- Table 7 - Navy non-validated operational requirements

where,

Frequency - Satellite geographic re-visit time

Timeliness - Satellite data in hands of user/processor before becoming perishable

Horizontal Resolution - The dimension of the smallest object (or horizontal area represented by the parametric value) which can be distinguished by a satellite sensor

Vertical Resolution - The smallest height increment discernible by a satellite sensor

Precision - The capability of defining the local gradient of the measurable oceanographic parameter. Precision is related to sensor sensitivity, digital quantization internal, and measurement noise

Absolute Accuracy - The measurement of the absolute value of an oceanographic parameter

Range - The bounds within which the measurements are to be taken.

Table 4
NAVY OCEANOGRAPHIC OPERATIONAL REQUIREMENTS
FOR ENVIRONMENTAL DATA MEASUREMENTS FROM SATELLITES *

PARAMETER		DATA RECEIPT RATE (HRS)		RESOLUTION		DEPTH (M)	MEASUREMENT			COVERAGE WINDOW (W) OR GLOBAL (G)
		FREQUENCY	TIMELINESS	HORIZONTAL (KM)	VERTICAL (M)		PRECISION	ABSOLUTE ACCURACY	RANGE	
SEA SURFACE TEMPERATURE		12	3	10	-	-	0.25°C	0.5°C	-2 to 35°C	G
		72	12	25			0.8°C	1.0°C		
SEA VERTICAL TEMPERATURE PROFILE		12	3	10	2	300	0.25°C	1.0°C	-2 to 35°C	G
		72	12	100	10	50	1.0°C	2.0°C		
WAVES	HEIGHT	3	0.5	1	-	-	0.3M	0.3M	1-20M	G/W
		12	3	25			10%	10%	1-8M	
	AMPLITUDE COMPONENT	3	0.5	1	-	-	0.3M	0.3 M	1-20M	G/W
		12	3	25			0.7M	0.7M	1-8M	
	WAVELENGTH COMPONENT	3	0.5	1	-	-	5%	5%	1-1000M	G/W
		12	3	25			15%	15%	50-500M	
	DIRECTION	3	0.5	1	-	-	10°	10°	0-360°	G/W
		12	3	50			30°	45°	0-360°	
SEA ICE	COVER	24	12	25/0.5**	-	-	10%	12%	0-100%	G/W
		120	24	25			25%	30%	0-100%	
	THICKNESS	24	12	2	-	-	0.25M	0.5M	0-25M	G/W
		120	24	50			2M	2M	30M	
	AGE	24	12	10	-	-	6 mos.	6 mos.	1-36 mos	G/W
		120	24	50			12 mos.	12 mos.	1-36 mos	
ICEBERGS & LEADS		24	3	0.015	-	-	-	0.5KM	-	W
		48	3	0.1				2KM		

* Block Identification - Top represents a tactical site with direct satellite readout.
- Bottom represents a central processing site for numerical processing.

** Fine horizontal resolution required for special operations.

TABLE 5

NAVY MARINE ATMOSPHERIC OPERATIONAL REQUIREMENTS

FOR ENVIRONMENTAL DATA MEASUREMENTS FROM SATELLITES*

PARAMETER		DATA RECEIPT RATE (HRS)		RESOLUTION		DEPTH (M)	MEASUREMENT			COVERAGE WINDOW (W) OR GLOBAL (G)
		FREQUENCY	TIMELINESS	HORIZONTAL (KM)	VERTICAL (M)		PRECISION	ABSOLUTE ACCURACY	RANGE	
CLOUD COVER** (including smoke, haze and smog)		On Call	0.08	0.5	-	TO DETECT ALL CLOUD LEVELS	-	0.5KM	-	W
		0.5	0.25	1				1.0KM		G/W
WIND	SPEED	3	0.25	10	-	-	5%	2M/SEC	1-75M/SEC	G
		12	3	25			20%	4M/SEC	1-25M/SEC	
	DIRECTION	3	0.25	10	-	-	5°	10°	0-360°	G
		12	3	25			10°	22.5°	0-360°	
VERTICAL TEMPERATURE PROFILE		1	0.5	10	30	0-60,000	1.0°C	10%	-70to50°C	W
		3	1	100	300					G/W
VERTICAL MOISTURE PROFILE		1	0.5	10	30	0-60,000	0.3MM	10%	-	W
		3	1	100	300					G/W
VISIBILITY***		1	0.25	10	-	0-7,500	-	-	-	W
										G/W
PRECIPITATION		On Call	0.25	1	-	-	0.3MM/HR	-	-	W
		3	1	5						G/W
SURFACE TEMPERATURE		1	0.5	10	-	-	0.5°C	0.5°C	-40°to60°C	G/W
		3	1	10			1.0°C	1.0°C		

* Block Identification - Top represents a tactical site with direct satellite readout
- Bottom represents a central processing site for numerical processing

** Visual and IR imagery

*** Discrimination between dense/thick/fog/mist with respect to poor/moderate/good/excellent

TABLE 6

NAVY TERRESTIAL OPERATIONAL REQUIREMENTS

FOR ENVIRONMENTAL DATA MEASUREMENTS FROM SATELLITES*

PARAMETER	DATA RECEIPT RATE (HRS)		RESOLUTION		DEPTH (M)	MEASUREMENT			COVERAGE WINDOW (W) OR GLOBAL (G)
	FREQUENCY	TIMELINESS	HORIZONTAL (KM)	VERTICAL (M)		PRECISION	ABSOLUTE ACCURACY	RANGE	
GEOID	Continuous	-	25	-	-	1CM	10%	-	G**
SNOW/ICE COVER	3	0.5	10	-	-	5CM	-	-	G
OVER LAND	6	1.5	45						
SOIL MOISTURE	On Call	0.25	2	-	-	10%	8CM	-	G
	6	1.5	10						

* Block Identification - Top represents a tactical site with direct satellite readout
- Bottom represents a central processing site for numerical processing

** One time global coverage

Table 7
NAVY NON-VALIDATED OPERATIONAL REQUIREMENTS
FOR ENVIRONMENTAL DATA MEASUREMENTS FROM SATELLITES*

PARAMETER		DATA RECEIPT RATE (HRS)		RESOLUTION		DEPTH (M)	MEASUREMENT			COVERAGE WINDOW (W) OR GLOBAL (G)
		FREQUENCY	TIMELINESS	HORIZONTAL (KM)	VERTICAL (M)		PRECISION	ABSOLUTE ACCURACY	RANGE	
SALINITY		12	3	10	2	300	1.0PPT	10%	-	G
		72	12	25	10	50				
OCEAN SURFACE CURRENTS	DIRECTION	12	3	10	-	-	10°	10°	-	G
		72	12	25			30°	45°		
	SPEED	12	3	10	-	-	0.5M/SEC	0.5M/SEC	-	G
		72	12	25			1.0M/SEC	1.0M/SEC		
WATER MASS IDENTIFICATION **		12	3	10	-	-	-	-	-	G
		72	12	25						
OCEAN TIDES		12	3	10	-	-	-	-	-	G
		24	6	25						
NEAR SHORE CURRENTS	DIRECTION	3	0.5	10M	1	30	10°	10°	-	W
		12	3	10M						G/W
	SPEED	3	0.5	10M	1	30	0.5M/SEC	0.5M/SEC	-	W
		12	3	10M						G/W
LITTORAL SEDIMENT TRANSPORT		3	0.5	10M	10	-	-	-	-	G/W
		12	3	10M						
NEAR SHORE BATHYMETRY***		ON CALL	0.25	25M	1	0-200	-	-	-	G
		-	-	300M						
WATER LEVELS		ON CALL	0.25	10	-	-	10%	0.15M	-	W

* Block Identification - Top represents a tactical site with direct satellite readout.
Bottom represents a central processing site for numerical processing.

** Color, plumes, fronts, and suspended sediments.

*** Once global coverage is obtained, the measurements are only on call.

R&D REQUIREMENTS

The Navy R&D requirements for oceanographic/marine atmospheric data are directly related to the required parameters that must be addressed and to the measurements that must be made to exploit existing satellites and satellites under development. The parameters are listed in priority order in Table 8 and their importance is as follows:

- Surface Winds. This is the highest priority parameter needed to provide the necessary information for current, wave, and upper layer mixing models. Assuming that surface temperature maps can be constructed, surface wind field data will assist the general circulation modeling efforts and the determination of the response of sea surface temperature to transient weather fronts.

- Surface Waves. This parameter is important with respect to knowing the directional-spectra characteristics for sea-air interaction research since one-directional spectra are of little use.

- Sea Surface Temperature. This parameter is needed to provide synoptic maps of surface manifestations or ocean weather maps. The ocean weather features of interest are mesoscale eddies and fronts and are the features most likely to have a significant effect on low frequency, long range acoustic propagation. The relationships between horizontal surface gradients and the vertical temperature structure is essential if remote surface temperature measurements are to be used in ocean dynamic studies. Once this is understood, remote sensing could become a key sensor for worldwide understanding of the general circulation of the ocean and ultimately being able to model and predict it.

- Sea Surface Topography. The fourth parameter will be used to help discern current boundaries, bottom topography, tides, and support geoidal studies.

- Other pertinent parameters are identified as footnotes in Table 5.

In addition, the required parameters for thermohaline models are summarized in Table 9 for accuracy, range, horizontal resolution, frequency, and area size.

R&D programs are required in a number of areas to exploit existing and imminent satellites for Navy oceanographic applications. These R&D programs require the following measurements:

- Infrared measurements for sea surface temperature mapping in support of ASW operations. The rationale and instrumentation aspects of obtaining sea surface temperature synoptically have been under development for the last twenty years. To a reasonable confidence level, the method has been demonstrated with the use of limited surface control points. Initiation of a global scale effort requiring absolute temperature measurements will require additional R&D in these areas:

Table 8

R&D REQUIREMENTS FOR ENVIRONMENTAL SATELLITE DATA

PARAMETER	MEASUREMENT ACCURACY	FREQUENCY OF COVERAGE	SPATIAL RESOLUTION	NEEDED FOR
SURFACE WINDS	Speed: 5 - 20% Direction: 5 - 20°	6 - 12 hours	10 - 100KM	General circulation and mixed layer modeling
SURFACE WAVE (Directional Spectra)	Estimate 2-dimensional spectrum with about 10 frequency and 10 directional components Amplitude = 5 - 10%	6 - 12 hours	10 - 100KM	Distribution of wave energy and its relation to winds
SEA SURFACE TEMPERATURE	1/4 - 3/4°C	Days to Month	1 - 20 KM	Mesoscale eddies and fronts Current boundaries
SEA SURFACE TOPOGRAPHY	10 CM or less	-	-	Geoid Tides Current boundary Bottom topography

NOTES: Lower priority parameters for physical oceanography: color (sediment and chlorophyll), salinity (water masses in conjunction with SST), waves (1-D spectra). Parameters not included above, but which are needed by physical oceanographers: cloudiness, surface air temperature and humidity (mixed layer modeling).

Table 9. NEEDED PARAMETERS FOR THERMOHALINE MODELS

PRIORITY	PARAMETER	ACCURACY	RANGE	HORIZ. RESOL.	FREQUENCY	AREA SIZE
1	REL. SST	.25°C 0.5°C	10°C 35°C	5 KM 30 KM	3 HR 12 HR	200 x 200 KM OCEAN BASIN
2	ABS. WIND STRESS VECT.	0.2 DYNES/CM^2 0.25 DYNES/CM^2	0-20 DYNES/CM^2 0-20 DYNES/CM^2	5 KM 30 KM	3 HR/15° 12 HR/45°	200 KM OCEAN BASIN
3	ICE COVER	% COVER % COVER	10% 10%	5 KM 30 KM	3 HR 12 HR	200 KM OCEAN BASIN
4	REL. SURFACE TOPO	3 CM 5 CM	1 METER 2 METERS	5 KM 30 KM	24 HR 72 HR	200 x 200 KM OCEAN BASIN
5	NET HEAT FLUX	10 CAL/CM^{2}DAY 20 CAL/CM^{2}DAY	5-100 5-100	5 KM 30 KM	12 HR 24 HR	200 KM OCEAN BASIN
6	ABS. SST	.5°C .5°C	0-35°C 0-35°C	5 KM 30 KM	3 HR 12 HR	200 KM OCEAN BASIN
7	INSOLATION	2 CAL/CM^2/DAY 5 CAL/CM^2/DAY	5-500 5-500	5 KM 30 KM	12 HR 24 HR	200 KM OCEAN BASIN
8	ABS. AIR TEMP	0.5°C 1.0°C	-50°C to 40°C -50°C to 40°C	5 KM 30 KM	3 HR 12 HR	200 KM OCEAN BASIN

	TEMP	1.0°C	-50°C to 40°C	30 KM	12 HR	OCEAN BASIN
9	BAROM. PRESSURE	5 MILLIBAR 5 MILLIBAR	960-1020 MB 960-1020 MB	5 KM 30 KM	3 HR 12 HR	200 KM OCEAN BASIN
10	RAIN	1 MM/HR 1 MM/HR	1-100 MM/HR 1-100 MM/HR	5 KM 30 KM	3 HR 12 HR	200 KM OCEAN BASIN
11	REL. HUMIDITY	5% 5%	0-100 0-100	5 KM 30 KM	3 HR 12 HR	200 KM OCEAN BASIN
12	CURRENTS	CM/SEC (10%) CM/SEC (20%)	4-400 4-400	5 KM 30 KM	3 HR/15° 12 HR/45°	200 KM OCEAN BASIN
13	SEA STATE HEIGHT	50 CM 50 CM	0-15 METERS 0-15 METERS	5 KM 30 KM	3 HR 12 HR	200 KM OCEAN BASIN
14	SALINITY	0.05% 0.1 %	0-40% 0-40%	5 KM 30 KM	3 HR 12 HR	200 KM OCEAN BASIN

-- Development of a method for obtaining standardized contact sea surface temperatures for control and implementation of a measurement quality assurance procedure. (Surface collected temperatures that form the FNWC data base are not all measured at the air/sea interface).

-- Complete error analysis of the spaceborne infrared scanner calibration.

-- Development of rationale, software, and data reduction procedures to compile maps or other presentation format.

-- Development of rationale and software to remove cloud data by using data from warmer, non-moving objects only (cloud pattern recognition or slicing).

-- Development of methodology for adjusting spaceborne data to surface data via best fit with useful cloudless and quality controlled ship or buoy reports thereby removing atmospheric effects.

-- Finally, the most difficult effort of developing structure functions through relationships with other environmental reports (winds, pressure, currents, bottom topography, etc.) must be accomplished in order to infer the ocean thermal and haline distributions. This total procedure should be accomplished in turn-around cycles of 12-24 hours for maximum usefulness in ASW operations.

Other available satellites can now be used to help develop the methodology, but the primary effort should probably be oriented to DMSP. Coincidental with the above process, atmospheric correction techniques must be perfected, including the following:

- Multifrequency microwave measurements through cloud cover for sea surface temperature, salinity, sea state, sea ice information. Cloud cover is the major limiting environmental factor for utilizing satellites for oceanographic applications. Although rigid theoretical analyses and extensive laboratory measurements have been accomplished indicating that the potential exists to obtain these needed parameters through cloud cover, insufficient field demonstration has taken place, to date. Tightly controlled field demonstrations must be undertaken utilizing aircraft microwave sensors. This will be a difficult and expensive task because of the many variables involved and the very extensive sea measurements required, but must be undertaken to establish reasonable levels of confidence. The effort is justified because of the unique atmospheric penetration capability that would be available. Following successful certification of engineering performance of these satellite sensors, it is necessary that geophysical validation experiments be conducted to evaluate data reduction algorithms for the measurement of ocean surface, meteorological, and terrestrial parameters. Geophysical validation of sensor performance requires surface measurement of the object parameter as well as of all conditions that will affect the sensor performance. For example,

calibration of a multifrequency passive microwave radiometer for measurement of sea surface temperature requires measurement of sea surface temperature, ocean surface salinity, surface wind speed, atmospheric temperature profile, atmospheric humidity profile, and integrated liquid water and water vapor in the atmospheric column. As another example, validation of synthetic aperture radar measurements of directional wave spectra requires surface measurement of the directional wave spectra; local wind speed, atmospheric parameters including liquid water, water vapor, temperature, and humidity profiles; and measurement of existing surface slicks.

- Continuous updating of knowledge related to coastal changes and processes requires higher spatial resolution imagery and increased manual interpretation than required for oceanic objectives. Current unclassified satellites with sufficient resolution are LANDSAT and possibly DMSP. Limited experimentation has been initiated into using LANDSAT for coastal purposes, such as the Pensacola test, but more work is necessary. Potential for automated remote turbidity measurement has been demonstrated. Success here could lead to improvement of circulation and sedimentation prediction capabilities for amphibious and mine warfare applications.

- The last area of needed R&D is the application for ice information. Like the coastal problem, increased spatial resolution and manual interpretation are indicated, not to identify the oceanic ice edge or perennially open ice areas in the Arctic, which can be done with grosser resolution using LANDSAT, but to infer ice mechanical properties. The state of the art for this purpose is based on a manual interpretation of ice pattern (roughness, ridge and lead density and geometry, etc.) which requires high spatial resolution imagery. Success here offers benefits for Arctic ASW and mine warfare objectives.

R&D OBJECTIVES

The overall goal of this Navy Satellite Oceanographic Research Program is to develop and demonstrate the effective use of satellite remote sensors in oceanographic research and in prediction for Naval operations. The R&D objectives which must be addressed to accomplish this overall goal are to demonstrate satellite sensing utility for determining and predicting:

I. Surface winds

II. Sea surface directional spectra

III. Oceanic thermohaline structure to depths of acoustic detection significance

IV. Coastal conditions of inshore warfare significance

V. Arctic ice conditions

VI. Other related research

A brief summary of the approach envisioned to accomplish each of these objectives is given in the following sections.

I. SURFACE WINDS

The approach is to use the SAR, scatterometer, and altimeter aboard SEASAT to develop a capability to infer surface winds based on sea surface spectra. In addition, it is expected that some benefit will be derived from the analysis of cloud pattern movement, as related to surface winds. Although some work has been accomplished to demonstrate promise for these approaches, major controlled experiments must be undertaken to prove the feasibility and determine the accuracy of these techniques.

II. SEA SURFACE DIRECTIONAL SPECTRA

The approach for this objective is to demonstrate the ability to measure sea surface directional spectra by placing the emphasis on the combined use of the Synthetic Aperture Radar (SAR), scatterometer, and altimeter aboard SEASAT. Verification of the data collected will be by conventional surface observations, classified satellite data, and aerial photography since available and foreseeable satellite visible and IR imagery lacks the spatial resolution required to discern waves less than 50 meters in wavelength.

III. OCEANIC THERMOHALINE STRUCTURE

The key to rapidly making a major step forward in accomplishing this objective is to capitalize on existing numerical models to accept satellite data in order to infer and predict subsurface conditions. The immediate model input parameters of concern are sea surface temperature, wind speed and direction, salinity, cloud cover, humidity, air temperature, and radiation. The clouds are the most significant problem in addition to the obvious limitation of attempting to use surface measurements for sub-surface inferences. It is felt that most visible

and IR data can be sufficiently corrected for normal atmospheric attenuation constraints. However, the future planning is to use microwave data that will penetrate and be correctable for all but the most severe rain clouds. SEASAT and future generations of DMSP will contain microwave sensors suitable for applicability evaluations. The program elements detailed in the Technical Plan cover the planned R&D investigations into the accuracies and applicability of various satellite sensors to provide the basic input parameters for the prediction models.

IV. COASTAL CONDITIONS FOR INSHORE WARFARE

The approach to accomplish this objective is to use higher resolution data because of the more complex patterns and smaller sizes of targets associated with the coastal ocean and land environment. The ability and applicability of the following satellite systems to this objective are as follows:

- LANDSAT has demonstrated some utility for automated classification of pertinent land features as well as certain water parameters.
- DMSP has some application in offshore objectives such as longshore currents and sediment transport.
- Classified systems are most applicable in the coastal terrain analysis problems and will be utilized, for this information.

V. ARCTIC ICE CONDITIONS

There are two facets associated with the approach to accomplish this objective. The first is to develop a capability to measure and interpret ice physical properties and the second is to predict ice movement and location. Existing visible and IR data from LANDSAT and DMSP are applicable in accomplishing this objective with cloud cover providing the major obstacle. These data and techniques would normally be verified by surface and sub-surface measurements and aircraft photography while classified satellite data could also be used. It is planned to implement controlled experiments with the SEASAT while Navy ROMS microwave sensors will be evaluated to determine their all weather capability. Classified satellite data will be fully evaluated for information content relative to ice physical properties.

VI. OTHER RELATED RESEARCH

The approach to accomplish this objective is to provide additional R&D to complement the prior five objectives in order to complete the requirements of the overall program.

TECHNICAL PROGRAM

Table 10 summarizes the objectives and program elements for the Navy Satellite Oceanographic Research Program (SOREP). The following thirty-two program elements comprise the SOREP and are listed in priority order.

1. Environmental Remote Sensing to Develop Sensors, Methods, and Display Techniques
2. Satellite Radar Altimetry
3. Environmental Remote Sensing to Determine Necessary Remote Sensors and Technique
4. Remote Ocean Surface Measurement System (ROMS)
5. SEASAT A Open Ocean Verification
6. Synthetic Aperture Radar Oceanographic Analysis
7. Signal Processing of Satellite Imagery for Oceanographic Information
8. Wave Spectra and Surf Dynamics
9. HF Radar Spectral Analysis for Remote Sea Sensing
10. Microwave Forward Scattering from the Ocean at Grazing Incidence
11. Microwave Forward Coherent and Incoherent Scatter from the Ocean
12. Delta-K Radar Development Program
13. Interactions Among Surface Water, Internal, and Electromagnetic Waves
14. Remote Synoptic Measurement of Sea Surface Currents
15. Sea Spectra Analysis for Wave Height Measurement
16. Water and Air Mass Properties and Dynamics
17. Environmental Sensor Assessment (Classified Project)
18. Ocean Thermohaline Distribution from Satellite Remotely Sensed Data
19. Water Vapor Corrections in the Thermal IR
20. Advanced Retrieval of Atmospheric Mass and Moisture Profiles
21. Remote Ocean Subsurface Temperature Profiler (ROSTEP)
22. Oceanographic Exploitation of Satellite Data
23. Bathemetry and Coastal Topography
24. Identify, Track, and Predict Iceberg Drift
25. Satellite Observations to Support Arctic Environmental Studies and Ice Prediction
26. Satellite Remote Sensing for Snow and Ice Cover Over Land
27. Satellite Altimeter Oceanographic Analysis
28. Multi-Spectral Remote Sensing of Atmospheric Constituents

29. Advanced Sensors for Atmospheric Temperature and Moisture Profiles

30. Position Determination of Satellite Remote Sensor Data

31. Interactive Graphics Display for Navy Environmental Requirements

32. Systems Upgrade for the SMQ-10 and TMQ-29

Each of these program elements has a particular strategy and time-framed tactics associated with it, which are fully described in Appendix B in Volume II. This approach has been taken to indicate the manner in which each program element and objective is expected to be accomplished in order to achieve the goals of the SOREP.

TABLE 10

OBJECTIVES AND PROGRAM ELEMENTS FOR THE NAVY SATELLITE OCEANOGRAPHIC RESEARCH PROGRAM

	NO.	TITLE
PROGRAM ELEMENTS	1	Environmental Remote Sensing to Develop Sensors, Methods, and Display Techniques
	2	Satellite Radar Altimetry
	3	Environmental Remote Sensing to Determine Necessary Remote Sensors and Technique
	4	Remote Ocean Surface Measurement System (ROMS)
	5	SEASAT A Open Ocean Verification
	6	Synthetic Aperture Radar Oceanographic Analysis
	7	Signal Processing of Satellite Imagery for Oceanographic Information
	8	Wave Spectra and Surf Dynamics
	9	HF Radar Spectral Analysis for Remote Sea Sensing
	10	Microwave Forward Scattering from the Ocean at Grazing Incidence
	11	Microwave Forward Coherent and Incoherent Scatter from the Ocean
	12	Delta-K Radar Development Program
	13	Interactions Among Surface Water, Internal, and Electromagnetic Waves
	14	Remote Synoptic Measurement of Sea Surface Currents
	15	Sea Spectra Analysis for Wave Height Measurement
	16	Water and Air Mass Properties and Dynamics
	17	Environmental Sensor Assessment (Classified Project)
	18	Ocean Thermohaline Distribution from Satellite Remotely Sensed Data
	19	Water Vapor Corrections in the Thermal IR
	20	Advanced Retrieval of Atmospheric Mass and Moisture Profiles
	21	Remote Ocean Subsurface Temperature Profiler (ROSTEP)
	22	Oceanographic Exploitation of Satellite Data
	23	Bathemetry and Coastal Topography
	24	Identify, Track, and Predict Iceberg Drift
	25	Satellite Observations to Support Arctic Environmental Studies and Ice Prediction
	26	Satellite Remote Sensing for Snow and Ice Cover Over Land
	27	Satellite Altimeter Oceanographic Analysis
	28	Multi-Spectral Remote Sensing of Atmospheric Constituents
	29	Advanced Sensors for Atmospheric Temperature and Moisture Profiles
	30	Position Determination of Satellite Remote Sensor Data
	31	Interactive Graphics Display for Navy Environmental Requirements
	32	Systems Upgrade for the SMQ-10 and TMQ-29

OBJECTIVES					
DEMONSTRATE SATELLITE SENSING UTILITY FOR DETERMINING AND PREDICTING:					
I	II	III	IV	V	VI
SURFACE WINDS	SEA SURFACE DIRECTIONAL SPECTRA	OCEANIC THERMOHALINE STRUCTURE	COASTAL CONDITIONS FOR INSHORE WARFARE	ARCTIC ICE CONDITIONS	OTHER RELATED RESEARCH
X	X	X	X	X	
X	X	X	X	X	
X	X	X	X	X	
X	X	X	X	X	
X	X	X			
X	X	X			
X	X	X			
X	X		X		
X	X			X	
X	X				
X	X				
X	X				
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			X		
					X
					X
					X
					X
					X
					X

OPERATIONAL AND DEVELOPMENTAL REMOTE SENSING SYSTEMS

EXISTING SYSTEMS

Data applicable to a wide range of Navy environmental research experiments are currently available from NASA, NOAA, and DoD satellites. These are listed with selected characteristics in Table 11. Potential applications include synoptic sea surface temperature, oceanic circulation, cloud cover and type, ice cover and type, mineral and organic turbidity, and shallow water-bottom topography. These satellites provide electronically transmitted data in the visible, near IR, thermal IR, microwave and radar bands. These satellites have both polar and geostationary orbits providing global data at intervals from thirty minutes to eighteen days. A myriad of formal and informal channels and handling procedures for accessing these data (between Navy users, via DoD, to civilian collectors) have evolved.

SYSTEMS UNDER DEVELOPMENT

Table 12 summarizes the satellite systems under development that can provide Navy environmental oceanographic and meteorological data and information. The utility of such systems ranges from minimal to high potential for future payoff.

SENSORS

The satellite deployed sensors currently available are covered in Table 11. Table 13 summarizes the projected satellite ocean boundary measurement capabilities expected in the 1978-1980 time frame. The available remote satellite sensor can be grouped into visible/IR sensors and microwave/radar sensors.

Visible/IR Sensors

Various visible/IR sensors have been developed for most of the orbiting and near-term launched satellites. Table 11 covered the presently available sensors while Table 14 summarizes the expected performance characteristics of visible/IR sensors to be deployed on satellites expected to be launched in the 1978-1979 time frame.

Microwave/Radar Sensors

Microwave sensors have only been deployed on the NIMBUS 5 and 6 satellite systems and their characteristics are covered in Table 11. However, microwave sensors will soon be deployed on the SEASAT-A and DMSP satellites. Table 15 summarizes the expected performance characteristics for the microwave sensors for satellites expected to be launched during the 1978-1979 time period.

Table 11

SATELLITE SYSTEMS AND SENSORS CURRENTLY AVAILA

SATELLITE	YEAR LAUNCHED	ORBIT TYPE	OPERATIONAL SENSORS	INSTRUMENT SENSING SPECTRAL BAND	RESOLUTION	SWATH
NIMBUS 5	1972	Polar	SCR	15um	-	-
			ESMR	19.7 GHz	20KM	NADI
			NEMS	55 GHz	150KM	NADI
NIMBUS 6	1975	Polar	THIR	6.5-7.0um	8 & 23KM	NADI
			THIR	10.5-12.5um	8 & 23KM	NADI
			PMR	15um	-	-
			ESMR	37 GHz	20KM	NADI
			ERB	-	-	-
LANDSAT 2	1975	Polar	MSS	0.4-1.1um	80M	160K
LANDSAT C	1978	Polar	MSS	0.5-1.1um	78KM	185K
			MSS	10.4-12.6um	78KM	185K
			RBV	0.5-0.75um	98x98KM	Camer
DMSP	1975	Polar	Visible & IR	0.5-1.1um	0.5 & 3KM	1500K
			Visible & IR	8-13um	0.5 & 3KM	1500K
NOAA 5	1976	Polar	SR	0.4-0.7 & 10.5-12.5um	4KM	1500K
			VHRR	0.6-0.7 & 10.5-12.5um	1KM	1500K
			VTPR	12,15, & 19um	55KM	NADIR
			SPM	-	-	-
SMS 1	1974	Geostationary 105° West	VISSR	0.55 - 0.75um	1,2, & 4KM	15,000
SMS 2	1975	Geostationary 135° West	VISSR	10.5 - 12.5um	8KM	15,000
GOES 1	1975	Geostationary 75° West	SEM	-	-	-
GOES 2	1977	Geostationary 49° West	SEM	-	-	-

ILABLE

ATH WIDTH	MEASUREMENT APPLICATION
-	Atmospheric CO_2
ADIR	Atmospheric water & ice boundaries
ADIR	Atmospheric temperature profile
ADIR	Atmospheric water & SST (Cloud free)
ADIR	Atmospheric water & SST (Cloud free)
-	Atmospheric CO_2
ADIR	Atmospheric water & ice boundaries
-	Solar data
160KM	Coastal & terrestrial imagery
185KM	Coastal & terrestrial imagery
185KM	Coastal & terrestrial imagery
Camera	Camera Photography
1500KM	Clouds & SST (Cloud free)
1500KM	Clouds & SST (Cloud free)
1500KM	Clouds & SST (Cloud free)
1500KM	Clouds & SST (Cloud free)
ADIR	Atmospheric temperature profile
-	Solar data
5,000KM	Clouds & SST (Cloud free)
5,000KM	Clouds & SST (Cloud free)
-	Solar data
-	Solar data

TABLE 12

SATELLITE SYSTEMS UNDER DEVELOPMENT

(1978-1979 LAUNCH PERIOD)

SATELLITE	APPROXIMATE LAUNCH DATE	TYPE SATELLITE SYSTEM
TIROS-N	3rd Qtr. 77	Meteorological-prototype for spacecraft in NOMSS series
SEASAT-A	5/78	Sea/Ocean Dynamics - first of planned operational satellite system
LANDSAT-C (ERTS-C)	78*	Land/Earth Resources - third in operational satellite system
NIMBUS-G	10/78	Meteorological - R&D satellite, basis for operational system
ITOS-I	1st Qtr. 78	Meteorological - third in NOMSS series
ITOS-J	12/79	Meteorological - fourth in NOMSS series
GOES-D (SMS-F)	78-79	Meteorological/Environmental - geosynchronous, NASA developed NOAA operated
DMSP-5D (4)	1st Qtr. 78	DoD Meteorological satellite
DMSP-5D (5)	2nd Qtr. 78	DoD Meteorological satellite
DMSP-5D (6)	1st Qtr. 79	DoD Meteorological satellite
DMSP-5D (7)	3rd Qtr. 79	DoD Meteorological satellite

TABLE 13

PROJECTED SATELLITE OCEAN BOUNDARY MEASUREMENT CAPABILITIES (1978-1980 TIME FRAME)

	Precision	Accuracy	Range	Resolution	Swath	Remarks
SST						
High-Resolution IR	0.5°C	3-6°C	-10° to 40°C	<1 km (n)	1800km	Regional coverage, TIROS-N, NOAA, DMSP
Global IR	0.5°C	3-6°C	-10° to 40°C	5 km (n)	1800km	TIROS-N, NOAA, DMSP
Corrected IR	0.5°C	1°C	- 5° to 35°C	>40 km (n)	1800km	Expected capability, derived data product, TIROS-N, DMSP
Geosynch. IR	0.5°C	3-6°C	-10° to 40°C	10 km (n)	50°cone	30-min. repeat coverage, 55° lat., GOES
SMMR (μwave)	1-1.5°C	1.5°C	- 5° to 35°C	125-150 km	600km	SEASAT, NIMBUS-G
SMMR-B (μwave)	1°C	1°C	- 5° to 35°C	70 km	600km	Proposed for SEASAT-B
ROMS (μwave)	0.5°C	1°C	- 5° to 35°C	10 km	1000km	Research objective - 1982
SURFACE WINDS						
SMMR-Wind speed	2m/sec	10%	4-30m/sec	50 km	600km	SEASAT, NIMBUS-G
SASS Wind speed	2m/sec	10%	4-25m/sec	50 km	1000km	SEASAT
Wind direction	20°	Ambiguity	0-360°	50 km	1000km	
SURFACE WAVES						
Sig. Wave height	1 m	-	0-15 m	10 km	Nadir	GEOS-3
Sig. Wave height	0.5 m	-	0-20 m	7 km	Nadir	SEASAT
SAR, Directional Wave Spectra h	TBD	-		-		Research objective - SEASAT is proof-of-concept experiment
2	25 m	-	50-700m	-	25 km	
θ	10°	-		-	frame	
OCEAN SURFACE TOPOGRAPHY						
GEOS-3	0.5m	*	-	10 km	Nadir-only	*Accuracy is function of orbit determination, and error contribution due to time-varying environmental factors.
SEASAT	0.1 m	*	-	7 km	Nadir-only	

Table 14

EXPECTED PERFORMANCE CHARACTERISTICS OF SATELLITE DEPLOYED VISIBLE/IR SENSORS
(1978 - 1979 EXPECTED LAUNCH PERIOD)

SENSOR	PLATFORM OR PROGRAM	APPROXIMATE LAUNCH DATE	WAVELENGTH MICRONS	SURFACE RESOLUTION	TYPE *
VIRR	SEASAT-A	5/78	0.52 - 0.73 10.5 - 12.5	4 km 8 km	I/S I/S
MSS	LANDSAT-C	78	0.5-0.6, 0.6-0.7, 0.7-0.8, 0.8-1.1 10.4 - 12.6	80 m 240 m	I/S I/S
RBV	LANDSAT-C	78	0.55 - 0.72 (3 cameras)	40 m	I/NS
CZCS	NIMBUS-G	10/78	0.433-0.453,0.51-0.53, 0.54-0.56, 0.66-0.68, 0.7-0.8, 10.5-12.5	830 m	I/S
THIR	NIMBUS-G	10/78	6.5 - 7.0 10.3 - 12.5	22 km 8 km	I/S I/S
SR	ITOS-I (NOAA-F) ITOS-J (NOAA-G)	1st Qtr 78 12/79	0.52 - 0.73 10.5 - 12.5	4 km 8 km	I/S I/S
VHRR	ITOS-I (NOAA-F) ITOS-J (NOAA-G)	1st Qtr 78 12/79	0.6 - 0.7 10.5 - 12.5	1 km 4 km	I/S I/S
VAS	GOES-D (SMS-F)	78-79	0.55 - 0.73 12.7 - 14.7	1 km 8 km	I/S I/S
AVHRR	TIROS-N	3rd Qtr 77	0.55 - 0.90 0.725- 1.0 10.5 - 11.5 3.44 - 3.93	1 km 1 km 1 km 4 km	I/S I/S I/S I/S
OLS	DMSP-5D (4 satellites #4-#7)	78-79	0.4 - 1.1 8 - 13	0.6 km (day) 2.7 km (night) 0.6 km	I/S I/S

SENSOR	PLATFORM OR PROGRAM	APPROXIMATE LAUNCH DATE	WAVELENGTH MICRONS	PURPOSE	TYPE*

SENSOR	PLATFORM OR PROGRAM	APPROXIMATE LAUNCH DATE	WAVELENGTH MICRONS	PURPOSE	TYPE*
ERB	NIMBUS-G	10/78	0.2 - 50 (22 chan.)	Earth Radiation Budget	NI/S
LIMS	NIMBUS-G	10/78	6.22(NO_2), 6.75(H_2O), 9.54(O_3), 11.3 (HNO_3), 14.93 and 15.21(CO_2)	Atmospheric Profiles	NI/S
SBUV	NIMBUS-G	10/78	.25 - .34 (12 chan.) .16 - .40	O_3 Profiles O_3 Profiles	NI/NS NI/S
TOMS	NIMBUS-G	10/78	.3125 - .38 (6 chan.)	Total O_3 Content	NI/S
SAMS	NIMBUS-G	10/78	4.3 and 15(CO_2), 5.3(NO), 7.7(CH_4), 4.5(CO), 2.7 and 25-100(H_2O), 7.7(N_2O)	Stratosphere, Mesosphere Sounder	NI/S
SAM II	NIMBUS-G	10/78	1.0	Stratospheric, Tropospheric Aerosols	NI/S
TOVS/BSU	NIMBUS-G	10/78	3.7 - 29.4 (14 Chan.)	Total O_3, H_2O vapor and Temperature profiles	NI/S
TOVS/SSU	NIMBUS-G	10/78	14.97 (3 Chan.)	Stratospheric Temperature Profiles	NI/S
VIPR	ITOS-I	1st Qtr 78	8.0 - 18.7 (8 Chan.)	Temperature profiles 0 - 30 km	NI/S
TOVS	ITOS-J	12/79	3.8 - 30 (17 Chan.)	Temperature, H_2O vapor, O_3 profiles	NI/S
SSH	DMSP-50	78-79	Several IR Chan.	Temperature, H_2O vapor profiles, total ozone	NI/S

* Type: I = Imaging, NI = Non-Imaging
S = Scanning, NS = Non-Scanning

TABLE 15

EXPECTED PERFORMANCE CHARACTERISTICS OF SATELLITE DEPLOYED MICROWAVE SENSORS

(1978-1979 EXPECTED LAUNCH PERIOD)

SENSOR	PLATFORM or PROGRAM	APPROXIMATE LAUNCH DATE	FREQUENCY GHz	RESOLUTION *	IFOV** (mr)	TYPE***
SAR	SEASAT - A	5/78	1.275	25 m	0.03	A/I/S
ALT	SEASAT - A	5/78	13.5	10 cm	-	A/NI/NS
SASS	SEASAT - A	5/78	14.595	50 km	25 deg.	A/NI/NS
SMMR	SEASAT - A	5/78	37, 21, 18, 10.7, 6.6	25-125 km	31	P/I/S
SMMR	NIMBUS - G	10/78	37, 21, 18, 10.7, 6.6	30-150 km	31	P/I/S
SSM	DMSP-5D (4) (5) (6) (7)	1st QTR 78 2nd QTR 78 1st QTR 79 3rd QTR 79	50-60 range 7 chan. 50-60 range 7 chan. 50-60 range 7 chan. 50-60 range 7 chan.	-	-	P/NI/S
TOVS/MSU	TIROS - N	3rd QTR 77	50.3, 53.74, 54.96, 57.95	-	-	P/NI/S

* Resolution is Surface Resolution except for Altimeter where altitude resolution is cited

** IFOV - Instantaneous Field of View (1 degree = 17.453 milliradians)

*** Type: A = Activve, P = Passive
I = Imaging, NI = Non-Imaging
S = Scanning, NS = None-Scanning

ISSUES REQURING ATTENTION

Having established the Navy requirements for environmental data, the data that can be furnished by satellites, and the existing or developmental sensors and satellites that can yield this data, it remains to address those key issues that require special attention by the Navy.

After careful consideration, it appears that there are four fundamental issues that require attention and resolution as soon as possible if the Navy environmental satellite research development program is to achieve its objectives in a timely and expeditious manner. The following sections cover these issues and the subsequent actions that are recommended.

ISSUES

The four issues requiring attention are as follows (not in priority order):

- Issue 1 - Satellite R & D Program Management. The major deficiency in the Navy's environmental satellite R&D program is that it lacks central management. The Navy programs are scattered throughout the Navy in organizations which report to different managers. The NERSCAC, as now constituted has neither the necessary authority or day-to-day continuity to effectively control the entire R&D program. There is not a single, authoritative, and responsible, designated manager for these programs who has line authority and budgetary control.

- Issue 2 - Data Throughput. Current and projected spaceborne sensors will yield enormous volumes of data. It appears to us that even the present data is not being processed, analyzed, or disseminated to the R&D community to its full extent. Part of this problem is due to the lack of a Navy centralized facility for the collection, processing, analysis, and distribution of satellite data.

- Issue 3 - Sensor Performance Verification. Because of the vast instantaneous coverage area of satellites, it becomes a major expensive task to handle this dynamic oceanographic situation. As a result, in addition to the centralized facility, there must be some means available, such as an ocean science satellite test range, to test and verify sensor performance against the SOREP objectives.

- Issue 4 - Data Validation. Sufficient ground truth data must be collected by scientific experiments to validate data obtained from spaceborne sensors. Furthermore, this data must establish, once and for all, whether spaceborne data can be extrapolated in a repetitive, predictable way to yield water column data.

RECOMMENDED ACTIONS

The following recommended actions should be implemented at the earliest practicable time by the Assistant Secretary of the Navy for Research, Engineering and Systems in order to address the previous four fundamental issues:

- Designate a line manager to direct and coordinate, on a full-time basis, all environmental satellite R&D programs within the Navy.

- Establish or designate a data management facility as the central facility to obtain, store, process, assess, and distribute satellite and other remote sensing R&D data, both classified and unclassified. This would create a contact point from which all Navy users could obtain other Governmental Agency satellite data. The center could archive copies of all documents, software programs, and data of significance to Navy developmental remote sensing programs. It would insure that the highest quality data were available for the users. This activity eventually would act as a dissemination point for the latest plans and news from within DoD and other satellite groups. A monthly technical information letter could be issued from this facility. It could organize quarterly technical seminars for information exchange for DoD and other scientists. It would serve as a ready, first level source of state-of-the-art status in this program for Navy management officials in the D.C. area. It is recommended that a secure facility staffed by one technically qualified professional who "knows everybody in the community" with appropriate contractor support be instituted. A location for the facility is not recommended at this time. However, the location must be chosen as to enable the center to function with the greatest impact and for the community. This professional would also act as the Navy point of contact for access to all satellite data.

- Establish an ocean science satellite test range to test and verify sensor performance against the SOREP objectives. This range should be chosen such that the proper oceanographic and meteorological instruments can be readily implemented to achieve the data collection and analysis and should be readily accessible to the Navy community.

- Plan or direct, as the highest priority R&D programs, those experiments which will determine the validity and usefulness of satellite data in naval applications.